



**UNIVERSITI PUTRA MALAYSIA**

**MARLING A REGOSOL OF CENTRAL JAVA AND ITS EFFECT  
ON MAIZE CROP PERFORMANCE**

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**MARLING A REGOSOL OF CENTRAL JAVA AND ITS EFFECT  
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**By**

**BAMBANG DJADMO KERTONEGORO**

**Thesis Submitted in Fulfilment of the Requirement for the Degree of Doctor of  
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**December 2000**



## **DEDICATION**

The author would like to dedicate this thesis entitled, “Marling A Regosol of Central Java and Its Effect on Maize Crop Performance”, to his alma mater, Gadjah Mada University, in Yogyakarta. He regards his alma mater as a prestigious community in which he and his family have been nurtured and guided towards a scientific and society oriented family.

Through this university too, the author has received opportunities to broaden his knowledge in Agricultural Science in general, and Soil Science in particular.

In this dedication, the author would like to express his sincere appreciation to his alma mater for her guidance and encouragement.

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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**December 2000**

**Chairman : Professor Wan Sulaiman Wan Harun, Ph.D.**

**Faculty : Agriculture**

In this study, a sandy soil (Regosol) derived from volcanic debris is amended with clay soils (Latosol and Grumusol) taken from different localities, with the objective of increasing the productivity of the Regosol as a marginal land.

Soil samples taken from the top 30 cm of the soil surface are dried, ground, and passed through a sieve with 2.0 mm openings. The Regosol is then thoroughly mixed with the Latosol or Grumusol based on oven weight percentage of 0%, 10%, 20%, 30%, 40%, 50%, and 100% of the Latosol or Grumusol.

Mineralogical analyses indicate that the sandy soil (Regosol) is mainly dominated by feldspars and cristobalite while the clay Latosol contains mainly 1:1 type clay minerals of the kaolinite type and most probably layers of halloysite, metahalloysite or kaolinite, with some cristobalite in it. The Grumusol, on the other hand, is dominated by open 2:1 clay minerals (swelling clay, smectite) mixed with 1:1 type such as halloysite, metahalloysite or kaolinite.

The addition of clay soils to the sandy soil changes the textural class towards clay. The particle density and the bulk density of the soil mixture decrease. The total porosity increases. The oxygen diffusion rate (ODR) in the soil mixture is influenced by the water content. Most of the ODR curves are lifted sharply when the matric potential decreases below  $-2$  kPa. The saturated hydraulic conductivity declines significantly after the addition of 10% to 20% of clay soils. Mixtures containing more than 40% clay soil show similar patterns as those of the original clay soils, while those containing less than 40% clay soil show intermediate behaviour between the sandy soil and the clay soils. The addition of 30% of clay soil causes a substantial reduction in the rate and maximum height of capillary rise during a ten-hour period of observation.

With increasing amounts of clay soils added, the Atterberg limits, namely the liquid limit (LL), sticky point (SP), and plastic limit (PL), generally increase with increasing amounts of clay soils added. The mechanical resistance declines when the condition is moist. When dry, Grumusol increases mechanical resistance substantially. The aggregate stability tends to decrease, even though there is a tendency for the number of aggregates each with a diameter bigger than 2.0 mm to increase. The response of the soil mixture to the Proctor standard compaction shows that 10% to 40% mixture of Latosol or 10% to 50% of Grumusol brings about an increase in dry soil bulk density. The maximum dry bulk density values of the mixtures are achieved at different critical moisture contents.

The pH of the mixture tends to shift towards those of the clay soils. The pH in the Latosol mixture decreases gradually from 6.33 to 5.97 due to the lower pH of Latosol than Regosol. In the Grumusol mixture, a 10% addition of Grumusol causes a substantial increase in the pH from 6.33 to 7.05 which is followed by a more gradual increase from 7.12 to 7.36. This may be the result of a dilution effect. The organic carbon and cation exchange capacity (CEC) increase linearly. The electrical conductivity (EC) shows a gradual increase, but in the Grumusol mixture the increase is more linear.

The results of the field experiment with maize reveal that an addition of 20% Latosol or 30% Grumusol are promising mixtures for increasing maize yields. These mixture percentages seem to have an optimum physical and chemical properties combination which is suitable for the growth of maize.

**Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia  
sebagai memenuhi keperluan untuk ijazah Doktor Falsafah**

**PEMARELAN TANAH REGOSOL DI JAWA -TENGAH DAN  
KEBERKESANANNYA ATAS TUMBESARAN TANAMAN JAGUNG**

**Oleh**

**BAMBANG DJADMO KERTONEGORO**

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Dalam kajian ini, tanah Regosol bertekstur pasir kasar hasil aktiviti gunung berapi, dicampur dengan tanah-tanah berkandungan lempung tinggi, iaitu Latosol ataupun Grumusol, dengan tujuan untuk meningkatkan produktivitinya. Sampel tanah diambil daripada tanah sedalam 30 cm. Tanah-tanah ini kemudiannya dikeringudara, ditumbuk, dan ditapis dengan tapisan 2.0 mm. Tanah pasir dicampur dengan tanah lempung samada Latosol atau Grumusol pada aras : 0%, 10%, 20%, 30%, 40%, 50%, dan 100% tanah lempung berdasarkan peratusan berat kering ketuhar. Percubaan menggunakan tanaman jagung juga dilakukan di ladang pada tanah-tanah campuran serupa.

Hasil-hasil kajian menunjukkan bahawa penambahan tanah lempung kepada tanah gunung berpasir kasar telah mengubah tekstur sehingga menjadi lempung. Ketumpatan zarah dan ketumpatan pukal menurun. Porositi keseluruhannya meningkat akibat penambahan tanah lempung. Laju difusi oksigen meningkat sedikit

sejajar dengan jumlah penambahan tanah lempung dan dengan berkurangnya kandungan air. Konduktiviti dalam keadaan tepu air menurun sejajar dengan jumlah penambahan tanah lempung yang diberikan. Penambahan 10% hingga 20% tanah lempung menurunkan secara nyata konduktiviti tepu air.

Nilai had Atterberg, iaitu, had cecair (LL), titik lekat (SP) dan had plastik (PL), pada amnya, selalu meningkat. Rintangan mekanik meningkat sejajar dengan berkurangnya kandungan air dan meningkatnya paras kandungan lempung. Dalam keadaan basah ataupun lembab, rintangan mekanik tertinggi pada tanah pasir tulin, kemudiannya diikuti pada campuran 20% dan 30%. Campuran tanah Grumusol menunjukkan rintangan mekanik (pada keadaan kering) yang lebih tinggi daripada campuran dengan Latosol.

Tindakbalas tanah campuran terhadap tenaga penumpatan meningkat apabila 10% hingga 40% tanah lempung Latosol diberikan, tetapi pada penambahan dengan Grumusol berkesan apabila 10% hingga 50% tanah diberikan. Penambahan tanah lempung melebihi 50% menunjukkan penumpatan tidak bertindakbalas. Penumpatan maksimum dicapai pada kandungan air yang berbeza-beza.

Nilai pH tanah meningkat dengan nyata daripada 6.33 ke 7.36 setelah dicampur dengan Grumusol dan menurun sedikit daripada 6.33 ke 5.97 setelah dicampur Latosol. Keupayaan pertukaran kation (KPK) meningkat secara linear, kandungan kapur meningkat secara kwadratik, bahan organik meningkat secara linear, dan begitu pula kandungan bes tertukarkan meningkat secara linear.



Paras campuran 20% bagi Latosol dan 30% bagi Grumusol memberikan pengaruh yang nyata bagi tumbesaran dan hasil tanaman jagung. Paras campuran ini paling berkesan, kerana ianya memberikan keadaan fizikal dan kemikal yang optimum bagi tanaman.

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I certify that an Examination Committee met on 12<sup>th</sup> December 2000 to conduct the final examination of Bambang Djadmo Kertonegoro on his Doctor of Philosophy thesis entitled "Marling A Regosol of Central Java and Its Effect on Maize Crop Performance" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Committee are as follows :

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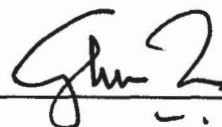
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**DECLARATION**

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

  
.....

Bambang Djadmo Kertonegoro

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## TABLE OF CONTENTS

	<b>Page</b>
DEDICATION.....	ii
ABSTRACT.....	iii
ABSTRAK.....	vi
ACKNOWLEDGEMENTS.....	ix
APPROVAL SHEETS.....	xi
DECLARATION FORM.....	xiii
LIST OF TABLES.....	xvii
LIST OF FIGURES.....	xviii
LIST OF PLATES.....	xxiii
LIST OF SYMBOLS.....	xxiv
LIST OF ABBREVIATIONS.....	xxv

## CHAPTER

1	INTRODUCTION.....	1.1
1.1	The World Population Growth.....	1.1
1.2	Limitation of Land Availability for Crop Production.....	1.2
1.3	Crop Production and World Requirement for Food.....	1.4
1.4	Objectives of the Study.....	1.7
2	LITERATURE REVIEW.....	2.1
2.1	Constraints of Sandy Soils.....	2.1
2.2	Techniques of Improving Sandy Soils .....	2.2
2.2.1	Application of Organic Materials .....	2.2
2.2.2	Application of Barrier Layers.....	2.4
2.2.3	Subsurface Soil Compaction.....	2.6
2.2.4	Profile Modification.....	2.7
2.2.5	Use of Artificial Soil Conditioners.....	2.8
2.2.6	Modification of Soil Texture.....	2.10
2.3	Crop Requirements for Maize .....	2.14
3	MATERIALS AND METHODS.....	3.1
3.1	Characterization of Soils Studied.....	3.1
3.1.1	Kalitirto Regosol.....	3.3
3.1.2	Patuk Latosol.....	3.5
3.1.3	Wonosari Grumusol.....	3.7
3.2	Geology of the Studied Area.....	3.9
3.3	Climatic Conditions of the Studied Area.....	3.12

3.4	Clay Mineralogical Characterization.....	3.14
3.5	Soil Physical Determinations.....	3.14
3.5.1	Soil Texture Analysis.....	3.14
3.5.2	Observation of Clay Migration in Soil Columns.....	3.15
3.5.3	Particle Density, Bulk Density, and Porosity.....	3.16
3.5.4	Microscopic Observation of Soil Pores.....	3.17
3.5.5	Structural Stability.....	3.18
3.5.6	The Soil Water Characteristic Curves and Field Capacity.....	3.20
3.5.7	Hydraulic Conductivity.....	3.23
3.5.8	Capillary Rise.....	3.24
3.5.9	Oxygen Diffusion Rate.....	3.25
3.6	Soil Mechanical Characterization .....	3.27
3.6.1	Atterberg Limits .....	3.27
3.6.2	Soil Compaction .....	3.27
3.6.3	Mechanical Resistance .....	3.29
3.7	Soil Chemical Determination .....	3.31
3.7.1	Soil pH .....	3.31
3.7.2	Organic Matter Content .....	3.31
3.7.3	Calcium Carbonate Content .....	3.31
3.7.4	Cation Exchange Capacity (CEC) .....	3.32
3.7.5	Salinity and Alkalinity .....	3.32
3.7.6	Gypsum Content .....	3.32
3.8	Field Experiment with Maize .....	3.34
3.9	Yields versus Soil Physico-Chemical Properties .....	3.36
4	RESULTS AND DISCUSSION .....	4.1
4.1	General Characteristics of the Soil Studied .....	4.1
4.2	Physical Characteristics of the Soil Mixtures .....	4.8
4.2.1	Soil Texture .....	4.8
4.2.2	Clay Migration during Watering .....	4.10
4.2.3	Particle Density, Bulk Density, and Porosity .....	4.14
4.2.4	Soil Pore Images from SEM .....	4.18
4.2.5	Saturated Hydraulic Conductivity ( $K_s$ ) ...	4.21
4.2.6	Unsaturated Hydraulic Conductivity ( $K_\theta$ ) .....	4.23
4.2.7	Capillary Rise .....	4.29
4.2.8	Soil Moisture Characteristic Curves, Pore Size Distribution, and AWC .....	4.32
4.2.9	Oxygen Diffusion Rate (ODR) .....	4.42
4.2.10	Structural Stability .....	4.44
4.3	Soil Mechanical Properties of the Soil Mixtures .....	4.49
4.3.1	Atterberg Limits .....	4.49
4.3.2	Compaction .....	4.53
4.3.3	Mechanical Resistance .....	4.56



4.3.4	Agro-management Aspects Related to Soil Physical Properties .....	4.60
4.4	Soil Chemical Properties of the Soil Mixtures ....	4.63
4.4.1	pH in Water .....	4.63
4.4.2	Organic Matter Content .....	4.64
4.4.3	Calcium Carbonate Content .....	4.65
4.4.4	Cation Exchange Capacity (CEC) .....	4.66
4.4.5	Content of Exchangeable Bases .....	4.67
4.4.6	Salinity and Alkalinity .....	4.70
4.4.7	Gypsum Content .....	4.71
4.4.8	Agro-management Aspects Related to Soil Chemical Properties .....	4.71
4.5	Yield of Maize from the Field Experiment .....	4.74
4.6	Yields versus Physico-Chemical Properties of Soil Mixtures .....	4.81
4.6.1	Stepwise Multiple Regression .....	4.82
4.6.2	Chosen Favourable Soil Parameters .....	4.83
4.6.3	Scoring Technique .....	4.86
4.7	Technical Possibility and Economical Feasibility of Marling .....	4.94
5	CONCLUSIONS AND RECOMMENDATIONS .....	5.1
	REFERENCES .....	R.1
	BIODATA OF THE AUTHOR .....	B.1

## LIST OF TABLES

Table	Page
1.1 Number and growth rate of population for the main islands in Indonesia (CBS,1991).....	1.1
1.2 Arable land per person in different countries in 1982 (FAO,1984) .....	1.4
2.1 Modification of soil available water capacity of gravelly sandy soil by the addition of ash (Winter, 1978) .....	2.11
4.1 Some physical and chemical properties of soil mixtures	4.2
4.2 Comparison between Field Capacity values obtained using pressure plate apparatus (at 10 kPa) and tensiometer method .....	4.33
4.3 Moisture content of soil mixtures at different matric potentials (kPa) determined using the hanging water column, pressure plate, and tensiometer .....	4.37
4.4 Pore size distribution of soil mixtures according to its function, calculated from Table 4.3 .....	4.38
4.5 The percentage of aggregates (> 2.0 mm), stability index, (SI), and stability quotient (SQ) of soil mixtures .....	4.48
4.6 Analytical characterization of the Kalitirto Regosol profile .....	4.75
4.7 Summarized data of crop performance indicators, physical and chemical properties of soil mixtures .....	4.84
4.8 Scoring range of soil physical and chemical properties for soil mixtures .....	4.87
4.9 The matrix of some soil properties for determining weight factors .....	4.88
4.10 The final score of some of soil properties .....	4.92

## LIST OF FIGURES

Figure	Page
3.1 Location map of the soil sampling sites .....	3.2
3.2 Geological map of Yogyakarta province (Kali Progo Basin Study Project, 1971) .....	3.10
3.3 Geological cross sections of the sampling sites (Kali Progo Basin Study Project, 1971) .....	3.11
3.4 Average monthly precipitation (a) and air temperature (b) distribution in the studied area represented by three meteorological stations, based on fifteen (Adisucipto), ten (Kalitirto), and thirteen (Wonosari) years of observation	3.13
3.5 A tensiometric observation method for determining the Field Capacity (FC) actual potential of a soil sample .....	3.22
3.6 Schematic diagram of a permeameter for determining the saturated hydraulic conductivity of soil samples in ring samplers .....	3.24
3.7 Schematic diagram of the ODR measurement set up on a sand-box apparatus .....	3.26
3.8 A standard Proctor compaction device scaled to length .....	3.28
3.9 Schematic diagram of (a) a penetrometer T-5001 and (b) a needle head .....	3.30
3.10 Diagrammatic layout of plots for maize grown on coarse sandy volcanic soil marled with clay soils .....	3.35
4.1 XRD-pattern of the clay fraction of Kalitirto Regosol after the DCB treatment .....	4.5
4.2 XRD-patterns of the clay fraction of Patuk Latosol without treatment (N), after treatment with DCB, saturated $Mg^{++}$ and $K^{+}$ , glycolation of the $Mg^{++}$ saturated sample and heating at 350 °C and 550 °C of the $K^{+}$ saturated sample	4.6

4.3 XRD-patterns of the clay fraction of the Wonosari Grumusol without treatment (N), after treatment with DCB, saturated $M^{++}$ and $K^+$ , glycolation of the $Mg^{++}$ saturated sample and heating at 350 °C and 550 °C of the $K^+$ saturated sample .....	4.7
4.4 The position of the textural classes of soil mixtures in the USDA textural class triangle, (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures .....	4.9
4.5 The clay content of the soil mixtures obtained from a laboratory analysis .....	4.9
4.6 Clay distributions in soil columns filled with Regosol-Latosol mixtures flushed with water at a constant flow .....	4.11
4.7 Clay distributions in soil columns filled with Regosol-Grumusol mixtures flushed with water at a constant flow ...	4.12
4.8 Particle density of soil mixtures .....	4.16
4.9 Bulk density of Regosol-Latosol mixtures related to the matric potentials .....	4.16
4.10 Bulk density of Regosol-Grumusol mixtures related to matric potentials .....	4.17
4.11 Total porosity of the Regosol-Latosol mixtures obtained by equation and by zero matric potential determination .....	4.17
4.12 Total porosity of Regosol-Grumusol mixtures obtained by equation and by zero matric potential determinations ...	4.18
4.13 Electron microscopic images (SEM) of Regosol-Latosol mixtures (magnification 20x) .....	4.19
4.14 Electron microscopic images (SEM) of Regosol- Grumusol mixtures (magnification 20x) .....	4.20
4.15 The evolution of the saturated hydraulic conductivity ( $K_s$ ) with time in Regosol-Latosol mixtures .....	4.22
4.16 The evolution of the saturated hydraulic conductivity ( $K_s$ ) with time in Regosol-Grumusol mixtures .....	4.22
4.17 Smoothened soil moisture characteristic curves or $h(\theta)$ curves of Regosol-Latosol mixtures obtained by the Van Genuchten model (1980) .....	4.25

4.18	Smoothened soil moisture characteristic curves or $h(\theta)$ curves of Regosol- Grumusol mixtures obtained by the Van Genuchten model (1980) .....	4.26
4.19	The $K(\theta)$ curves of Regosol-Latosol mixtures obtained by the Mualem model (1976) .....	4.26
4.20	The $K(\theta)$ curves of Regosol-Grumusol mixtures obtained by the Mualem model (1976) .....	4.27
4.21	The $K(h)$ curves of Regosol-Latosol mixtures obtained by the Mualem model (1976) .....	4.27
4.22	The $K(h)$ curves of Regosol-Grumusol mixtures obtained by the Mualem model (1976) .....	4.28
4.23	The $D(\theta)$ curves of Regosol-Latosol mixtures obtained by the Mualem model (1976) .....	4.28
4.24	The $D(\theta)$ curves of Regosol-Grumusol mixtures obtained by the Mualem model (1976) .....	4.29
4.25	The relationship between the height of capillary rise and the square root of time in Regosol-Latosol mixtures .....	4.31
4.26	The relationship between the height of capillary rise and the square root of time in the Regosol-Grumusol mixtures.....	4.31
4.27	Soil moisture characteristic curves of Regosol-Latosol mixtures.....	4.34
4.28	Soil moisture characteristic curves of Regosol-Grumusol mixtures.....	4.34
4.29	Pore volume distribution in (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures (FC at 10 kPa) .....	4.40
4.30	Pore volume distribution in (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures (FC from tensiometer reading) .....	4.41
4.31	Oxygen diffusion rate (ODR) in Regosol-Latosol mixtures at different matric potentials .....	4.43
4.32	Oxygen diffusion rate (ODR) in Regosol-Grumusol mixtures at different matric potentials .....	4.43

4.33 Curves of the cumulative weight percentage of soil aggregates obtained from dry (—) and wet sieving (— —) of Regosol-Latosol mixtures .....	4.46
4.34 Curves of the cumulative weight percentage of soil aggregates obtained from dry (—) and wet sieving (— —) of Regosol-Grumusol mixtures .....	4.47
4.35 Liquid limit (LL) of soil mixtures .....	4.50
4.36 Plastic limit (PL) of soil mixtures .....	4.50
4.37 Sticky point (SP) of soil mixtures .....	4.52
4.38 The workability coefficient (WC) of soil mixtures ....	4.53
4.39 Relationship between soil moisture content and dry bulk density of (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures after Proctor standard compaction treatments .....	4.54
4.40 Soil moisture content of (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures prior to the penetration resistance measurement .....	4.57
4.41 Mechanical resistance of (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures at different moisture conditions measured by a needle penetrometer	4.58
4.42 Model of a soil aggregate with its possible binding materials (after Emerson, 1977) .....	4.59
4.43 The pH (in H <sub>2</sub> O) of soil mixtures .....	4.64
4.44 The organic matter content of soil mixtures .....	4.65
4.45 The CaCO <sub>3</sub> content of soil mixtures .....	4.66
4.46 The Cation Exchange Capacity (CEC) of soil mixtures	4.67
4.47 The exchangeable Ca of soil mixtures .....	4.68
4.48 The exchangeable Mg of soil mixtures .....	4.68
4.49 The exchangeable K of soil mixtures .....	4.69
4.50 The exchangeable Na of soil mixtures .....	4.69

4.51 The electrical conductivity (1:5) of soil mixtures .....	4.70
4.52 Daily precipitation distribution at the Kalitirto experimental station during the maize growing period from July to December 1999 .....	4.76
4.53 Height of maize plant measured at the age of 40 days and at harvest, on (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures .....	4.78
4.54 Weight of corn grains and cob obtained from each soil treatment on (a) Regosol-Latosol mixtures and (b) Regosol-Grumusol mixtures .....	4.79
4.55 Weight of maize shoot per plant .....	4.81
4.56 Grain weight and fertility score on Regosol-Latosol mixtures .....	4.93
4.57 Grain weight and fertility score on Regosol-Grumusol mixtures .....	4.93

## LIST OF PLATES

<b>Plate</b>	<b>Page</b>
3.1 General landscape (a) and microtopography (b) of the sampling site of Kalitirto Regosol .....	3.4
3.2 General landscape (a) and microtopography (b) of the sampling site of Patuk Latosol .....	3.6
3.3 General landscape (a) and microtopography (b) of the sampling site of Wonosari Grumusol .....	3.8



## LIST OF SYMBOLS

$\rho_s$	soil particle density, $\text{Mg m}^{-3}$
$\rho_b$	soil dry bulk density, $\text{Mg m}^{-3}$
$n$	total porosity, %
$K_s$	saturated hydraulic conductivity, $\text{cm h}^{-1}$
$K(h)$	hydraulic conductivity as a function of matric potential
$K(\theta)$	hydraulic conductivity as a function of moisture content
$D(\theta)$	diffusivity as function of soil moisture
$A$	cross section area of a soil sample perpendicular to the direction of water flow, $\text{cm}^2$
$L$	length of soil sample, cm
$\Delta H$	hydraulic head difference, cm
$Q$	volume of water passing through the cross sectional area of the soil sample perpendicular to the direction of water flow, $\text{cm}^3$
$\Psi_m$	matric potential, - cm $\text{H}_2\text{O}$ or kPa
$\Psi(\theta)$	matric potential as a function of moisture content
$h$	matric head, - cm $\text{H}_2\text{O}$ or kPa
$i$	observed microelectrode current, $\mu\text{A}$
pH	unit of acidity